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Free-ranging dogs as drivers of wildlife disturbance in an urban Atlantic Forest remnant.

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Abstract

Free-ranging domestic dogs are an increasing threat to biodiversity, public health, and animal welfare worldwide, particularly in fragmented landscapes near urban areas. In Brazil, where the dog population exceeds 58 million individuals, many dogs roam freely through streets and natural habitats. Here, we evaluated the relationship between free-ranging dog occurrence and wildlife species richness in an urban Atlantic Forest fragment at the Botanical Garden of the Federal University of Juiz de Fora, southeastern Brazil. Using camera traps between December 2022 and May 2024, we obtained 4,137 records and identified 22 vertebrate species. Domestic dogs were among the most frequently recorded taxa and occurred on all monitored trails. Wildlife species richness was negatively associated with dog occurrence, with trails showing higher dog activity supporting lower vertebrate richness. Temporal overlap between dogs and nocturnal wildlife species also suggested potential behavioral interference. Our findings indicate that free-ranging dogs may disrupt wildlife communities in urban forest remnants and reinforce the importance of management strategies that reduce dog intrusion into protected areas. Integrating biodiversity conservation, responsible ownership, and animal welfare measures will be essential for maintaining ecological integrity in biodiversity hotspots such as the Atlantic Forest.

1. Introduction

Biological invasions are among the leading drivers of global biodiversity loss, particularly in fragmented landscapes where native species are already under pressure from habitat degradation, urban expansion, and increasing human disturbance (Bellard et al. 2016, Doherty et al. 2016). Invasive and human-associated species can alter ecological communities through predation, competition, disease transmission, and behavioral interference, leading to shifts in species occurrence, trophic interactions, and local extinctions (Gurevitch and Padilla 2004, Dick et al. 2017). In urbanized environments, these processes may also promote biotic homogenization by favoring disturbance-tolerant species while reducing the persistence of more sensitive native taxa. Such impacts are especially concerning in tropical biodiversity hotspots, where habitat fragmentation and anthropogenic pressures already compromise ecological integrity (Vancine et al. 2024).

The Atlantic Forest of Brazil is one of the world's most threatened biodiversity hotspots, retaining only a small fraction of its original vegetation cover (Ribeiro et al. 2009, Vancine et al. 2024). Despite intense deforestation and urbanization, the biome still supports exceptionally high levels of species richness and endemism (Paglia et al. 2008, Bello et al. 2015). Much of the remaining forest persists as small and isolated fragments embedded within human-modified landscapes, where wildlife populations are exposed to edge effects, habitat degradation, and frequent human disturbance. Under these conditions, protected areas located near urban centers may function as important refuges for native fauna, although they are increasingly permeable to invasive alien species associated with human activities (McKinney 2006, Joppa and Pfaff 2011). Recreational trails and access routes may further facilitate the movement of invasive and human-associated species into forest interiors, intensifying ecological disturbances within remnant habitats.

Among human-associated invasive species, free-ranging domestic dogs (*Canis familiaris*) are globally widespread and recognized as important drivers of wildlife decline (Doherty et al. 2017). Unlike native predators, free-ranging dogs are often subsidized by humans through food provisioning, shelter, and access to urban infrastructure, allowing populations to persist at artificially high densities even in disturbed environments. In Brazil alone, the dog population exceeds 58 million individuals (ABINPET 2023), and many dogs roam freely through urban, peri-urban, and natural areas. These animals can negatively affect wildlife through predation, harassment, competition, disease transmission, and spatial or temporal interference, including within protected areas and biodiversity refuges (Srbek-Araujo and Chiarello 2008, Massara et al. 2016, Doherty et al. 2016). Their presence may alter species behavior, reduce habitat use by sensitive fauna, and compromise the effectiveness of protected areas for biodiversity conservation.

Despite growing evidence of the ecological impacts of free-ranging dogs, quantitative assessments in small urban forest remnants remain limited, particularly in tropical biodiversity hotspots such as the Atlantic Forest. Understanding how dog occurrence relates to wildlife distribution in these landscapes is important for evaluating the conservation value of urban protected areas and the vulnerability of native communities to invasive predators.

Here, we evaluated the relationship between free-ranging domestic dogs and vertebrate communities in an urban Atlantic Forest fragment in southeastern Brazil. Specifically, we investigated whether dog occurrence was associated with reduced wildlife species richness and whether trails with greater human accessibility intensified this relationship. We predicted that trails with higher dog occurrence would support lower vertebrate richness, particularly among disturbance-sensitive species, due to increased anthropogenic pressure and ecological disturbance associated with dog intrusion.

2. Methods

2.1 Study area

The study was conducted at the Botanical Garden of the Federal University of Juiz de Fora (BG-UFJF; 21°44'15.5"S, 43°22'10.4"W), Minas Gerais, southeastern Brazil. The BG-UFJF comprises approximately 82 ha of secondary Atlantic Forest undergoing natural regeneration following historical deforestation and agricultural land use. The area is embedded within an urban matrix and connected to the Krambeck Forest State Park, a 291-ha Atlantic Forest remnant that represents one of the largest forest fragments in the region.

We monitored four forest trails that differed in levels of human accessibility and visitor use: two open to public visitation (Açude and Juçara) and two with restricted access and lower human activity (Figueira and Portão) (Fig. 1). This configuration allowed comparisons across a gradient of anthropogenic disturbance and human-mediated access within the forest fragment.

2.2 Camera trapping and data collection

Camera traps were deployed between December 2022 and May 2024, totaling 972 camera-days after excluding periods of equipment malfunction. Sampling effort differed among trails due to accessibility and logistical constraints, with Figueira trail receiving the highest sampling effort (Table 1).

Table 1
Capture effort per trail and total sampling effort in the Botanical Garden of the Federal University of Juiz de Fora (BG-UFJF), expressed as camera-days.

Trail	2022	2023	2024	Total
Figueira	31	455	273	759
Açude	31	92	-	123
Juçara	-	59	-	59
Portão	-	-	31	31
Total	-	-	-	**972**

Cameras were positioned along animal movement routes approximately 45 cm above ground level and operated continuously without bait or attractants. For each independent detection, we recorded species identity, date, time, trail, and presence of humans. Domestic dog records were used to calculate a Relative Abundance Index (RAI), expressed as the number of independent records per 100 camera-days (Srbek-Araujo and Chiarello 2005).

To account for unequal sampling effort among trails, wildlife species richness was estimated using a resampling approach based on rarefaction methods (Gotelli and Colwell 2001). The procedure consisted of randomizing all records, sampling 100 records without replacement, estimating species richness, and repeating the process 1,000 times. Domestic dog records were excluded from richness estimates. Due to limited sampling effort, the Portão trail was excluded from richness comparisons. We also qualitatively assessed temporal overlap between domestic dogs and the most frequently detected wildlife species by visually comparing diel activity patterns.

2.3 Statistical analysis

Differences in wildlife species richness among trails were evaluated using analysis of variance (ANOVA) followed by Tukey's post hoc tests. To examine the relationship between free-ranging dog occurrence and wildlife richness, we fitted generalized linear models (GLMs) using wildlife species richness as the response variable and dog frequency as the explanatory variable.

Because richness data showed overdispersion under a Poisson distribution, we used a negative binomial GLM implemented with the function glm.nb() in the MASS package (Ripley et al. 2013). Wildlife richness

estimates generated from the resampling procedure were used as the response variable. All analyses were conducted in R version 4.5.2 (R Core Team 2025).

3. Results

A total of 4,137 camera-trap records were obtained across the four monitored trails at BG-UFJF, of which 2,732 corresponded to animal detections. We recorded 22 vertebrate taxa, including 15 mammals, five birds, one reptile, and one amphibian species. Free-ranging domestic dogs (*Canis familiaris*) were among the most frequently detected taxa in the study area, presenting the third highest Relative Abundance Index (RAI) overall. Dogs were recorded on all monitored trails, including both public-access and restricted-access areas, with the highest occurrence observed on Juçara and Figueira trails.

The most frequently detected native species were the white-eared opossum (*Didelphis albiventris*), tapiti (*Sylvilagus brasiliensis*), coati (*Nasua nasua*), and Jacu (*Penelope obscura*). Carnivore records included ocelots (*Leopardus pardalis*), pumas (*Puma concolor)*, tayras (*Eira barbara*), and crab-eating foxes (*Cerdocyon thous*), although all occurred at low frequencies (Table 2).

Table 2

Relative Abundance Index (RAI) of species recorded by camera traps in the JB-UFJF. Species were ranked from highest to lowest RAI to identify the most frequently detected taxa in the study area.

Species	Commom name	Total records	Total camera-days	RAI
Didelphis albiventris (Wied-Neuwied, 1826)	**"white-eared opossum"**	**66**	**941**	**7.01**
Sylvilagus brasiliensis (Linnaeus, 1768)	**"tapiti"**	**63**	**972**	**6.48**
Canis familiaris (Linnaeus, 1758)	**"domestic dog"**	**52**	**972**	**5.35**
Nasua nasua (Linnaeus, 1766)	"coati"	40	849	4.71
Penelope obscura Temminck, 1815	"Jacu"	40	941	4.25
Dasypus novemcinctus Linnaeus, 1758	"armadillo"	1	31	3.23
Cuniculus paca (Linnxaeus, 1766)	"spotted paca"	25	818	3.06
Turdus rufiventris Vieillot, 1818	"Rufous-bellied thrush"	26	913	2.85
Salvator merianae (Duméril & Bibron, 1839)	"teiu"	8	759	1.05
Aramides saracura (Spix, 1825)	"Slaty-breasted wood rail"	9	941	0.96
Vanellus chilensis (Molina, 1782)	"Southern lapwing"	1	123	0.81
Puma concolor (Linnaeus, 1758)	"puma"	7	882	0.79
Leopardus pardalis (Linnaeus, 1758)	"ocelot"	5	759	0.66
Hydrochoerus hydrochaeris (Linnaeus, 1766)	"capybara"	3	882	0.34
Tamandua tetradactyla (Linnaeus, 1758)	"collared anteater"	2	759	0.26
Non-identified	"bat"	1	759	0.13
Felis catus (Linnaeus, 1758)	"domestic cat"	1	759	0.13
Non-identified	"frog"	1	759	0.13
Non-identified	"humming-bird"	1	759	0.13
Panthera onca (Linnaeus, 1758)	"jaguar"	1	759	0.13
Eira barbara (Linnaeus, 1758)	"tayra"			
Cerdocyon thous (Linnaeus, 1766)	"crab-eating fox"			

Temporal activity patterns revealed substantial overlap between domestic dogs and predominantly nocturnal species such as *D. albiventris* and *S. brasiliensis*. In contrast, lower temporal overlap was observed between dogs and primarily diurnal species such as *N. nasua* and *P. obscura* (Fig. 2), suggesting potential temporal partitioning or reduced exposure among diurnal taxa.

Wildlife species richness differed significantly among trails (ANOVA: $F_{2,297} = 368.0$, $p < 0.001$). The restricted-access Figueira trail showed the highest estimated richness (9.61 ± 1.59 SD), followed by the public-access Açude trail (8.63 ± 0.51 SD) and the Juçara trail (6.63 ± 0.54 SD). Tukey's post hoc tests indicated significant differences among all pairwise trail comparisons (Table 3). Wildlife richness was negatively associated with domestic dog occurrence (estimate = − 0.035 ± 0.007 SE, z = − 4.67, $p < 0.001$; Fig. 3), with trails presenting higher dog activity supporting lower vertebrate richness overall.

Table 3
Tukey's test comparing among free access and restricted access trails on the vertebrate species richness (mammals and birds) at BG-UFJF.

Comparison	N*	Difference	Lower Limit	Upper Limit	p-value
Figueira – Açude	100	0.91	0.641	1.179	< 0.001
Juçara – Açude	100	-2.11	-2.379	-1.841	< 0.001
Juçara – Figueira	100	-3.02	-3.289	-2.751	< 0.001

*Bootstrap analysis with 100 iterations, each sampling 100 random observations per trail.

4. Discussion

Our results demonstrate a strong negative association between free-ranging domestic dogs and wildlife species richness within an urban Atlantic Forest fragment, reinforcing growing evidence that dogs function as important sources of anthropogenic disturbance in protected areas and fragmented landscapes (Lessa et al. 2016, Doherty et al. 2017, Weng et al. 2022). Dogs were detected on all monitored trails, including restricted-access areas, indicating high permeability of the forest fragment to human-associated predators. Trails with greater human accessibility showed lower vertebrate richness overall, suggesting that human use and dog intrusion may jointly intensify ecological disturbance within urban forest remnants.

Free-ranging dogs can affect wildlife through multiple ecological pathways, including predation, harassment, competition, disease transmission, and behavioral disruption (Doherty et al. 2017, Paschoal et al. 2012). Unlike native predators, however, dog populations are frequently subsidized by humans through food availability, shelter, and access to urban infrastructure, allowing them to persist at artificially high densities even in highly disturbed environments. This human support may amplify ecological impacts on native fauna, particularly in fragmented habitats where wildlife populations are already vulnerable to edge effects and anthropogenic pressures.

Although direct predation events were not recorded in our study, temporal overlap between dogs and nocturnal species such as opossums and tapitis suggests potential interference in habitat use and activity patterns. Similar behavioral responses have been documented in other Neotropical protected areas, where wildlife species reduced habitat use or shifted temporal activity in response to free-ranging dogs and other human-associated predators (Massara et al. 2016, Lessa et al. 2016). Such non-lethal effects may alter energy expenditure, resource use, and species interactions, potentially contributing to long-term ecological changes even in the absence of direct mortality.

These impacts may be particularly severe in the Atlantic Forest, one of the world's most fragmented biodiversity hotspots (Ribeiro et al. 2009, Vancine et al. 2024). Most remaining forest patches are small, isolated, and embedded within human-modified landscapes, conditions that facilitate the penetration and persistence of invasive and disturbance-tolerant species (Didham et al. 2007). In urban remnants, recreational trails and forest edges may increase landscape permeability to dogs, intensifying human-mediated disturbance inside protected areas. Over time, these processes may contribute not only to reductions in local richness but also to biotic homogenization, favoring generalist and disturbance-tolerant taxa while reducing the persistence of more sensitive native species.

The higher vertebrate richness observed on restricted-access trails suggests that limiting human and dog intrusion may provide important refuges for wildlife persistence, even at relatively small spatial scales. Although some adaptable species persisted in areas with high dog occurrence, less tolerant species may be progressively displaced, potentially altering local community structure and ecological interactions (Monteiro-Alves et al. 2021). Such patterns are especially concerning in urban protected areas, where continued urban expansion may further increase contact among humans, dogs, and wildlife.

The ecological impacts of free-ranging dogs are also closely linked to animal welfare and public health concerns. In Brazil, many dogs roam freely due to abandonment, inadequate containment, and limited responsible ownership practices (Mota-Rojas et al. 2021, Ferreira Siano et al. 2024). These animals are themselves exposed to poor welfare conditions, including disease, malnutrition, and vehicle collisions, while also acting as potential reservoirs for pathogens affecting wildlife, domestic animals, and humans (Chomel 2014, Ellwanger and Chies 2019). Consequently, management strategies should integrate biodiversity conservation, public health, and animal welfare perspectives rather than relying exclusively on lethal control approaches.

Management measures such as sterilization campaigns, vaccination programs, responsible ownership education, and stricter control of dog access to protected areas may help reduce ecological impacts while improving animal welfare outcomes (Contreras-Abarca et al. 2022). In urban protected areas such as BG-UFJF, fine-scale management actions, including visitor regulation and restriction of dog access to sensitive trails, may provide practical conservation benefits at local scales.

Our study was based on a single urban forest fragment and used a correlational approach, limiting causal inference regarding dog impacts on wildlife communities. Nevertheless, the consistent negative

relationship between dog occurrence and vertebrate richness highlights the potential importance of free-ranging dogs as drivers of ecological disturbance in fragmented tropical landscapes. Future studies integrating ecological, epidemiological, and social dimensions across multiple urban remnants could improve understanding of human–dog–wildlife interactions and support more effective conservation planning in biodiversity hotspots.

Declarations

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Competing Interests

The authors have no competing interests to declare that are relevant to the content of this article.

Author contributions

Conceptualization and Literature Search, L.S.G., M.C.R., and A.C.S.; Data collection and Data Analysis, L.S.G., J.P.A.D., C.A.R., M.C.R.; writing original draft preparation, L.S.G., J.P.A.D., C.A.R., F.P., A.C.S., and C.R.D.; preparation of English version, L.S.G., J.P.A.D., A.C.S., and C.R.D.; writing—review and editing, L.S.G., J.P.A.D., M.C.R., F.P., A.C.S., and C.R.D.

All authors agree to be held accountable for the content therein and approve the final version of the manuscript.

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Figures

Figure 1. Location of UFJF Botanical Garden in Juiz de Fora, Minas Gerais, Brazil.

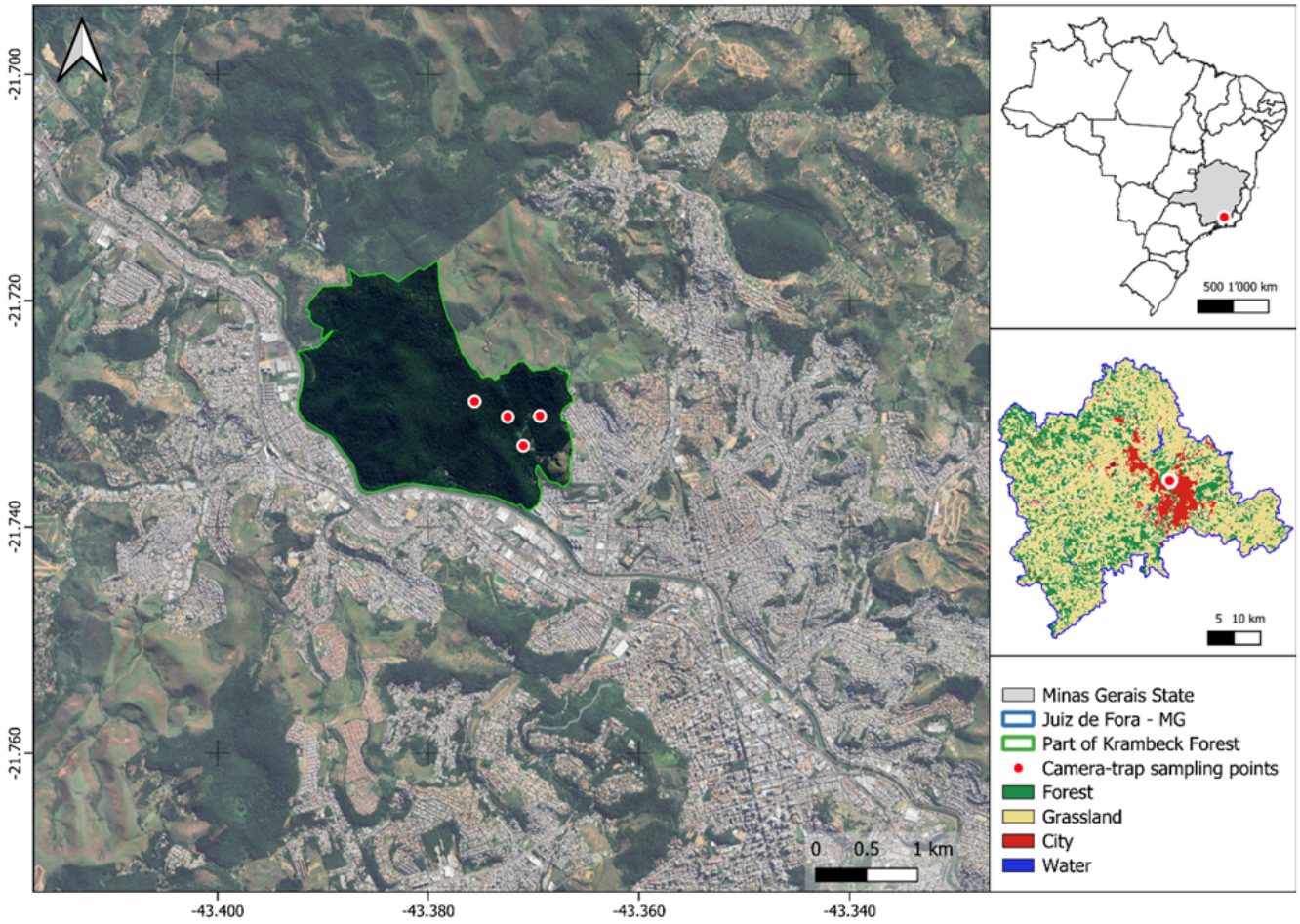


Figure 1

See image above for figure legend.

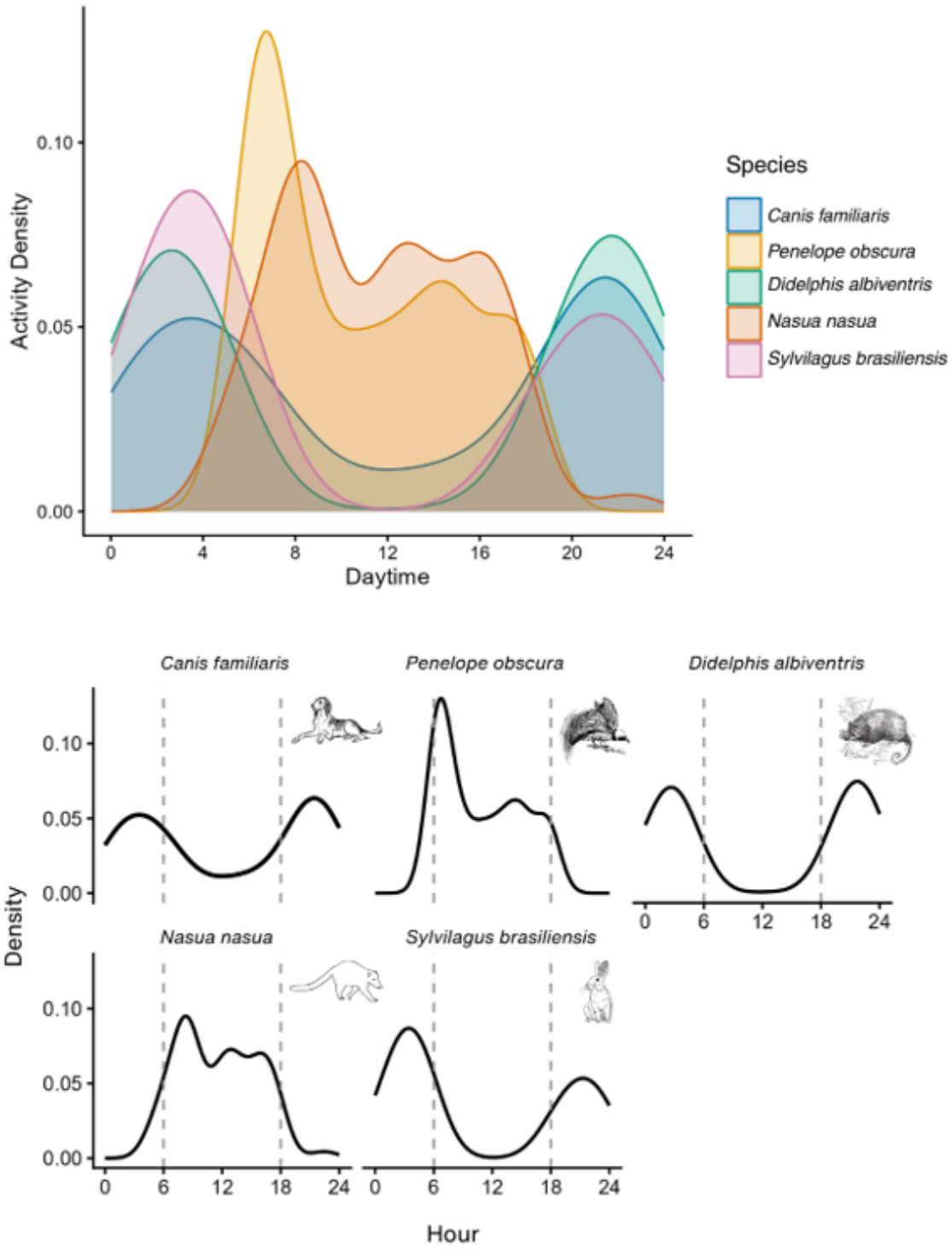


Figure 2

Temporal activity patterns of the most abundant species recorded in BG-UFJF.

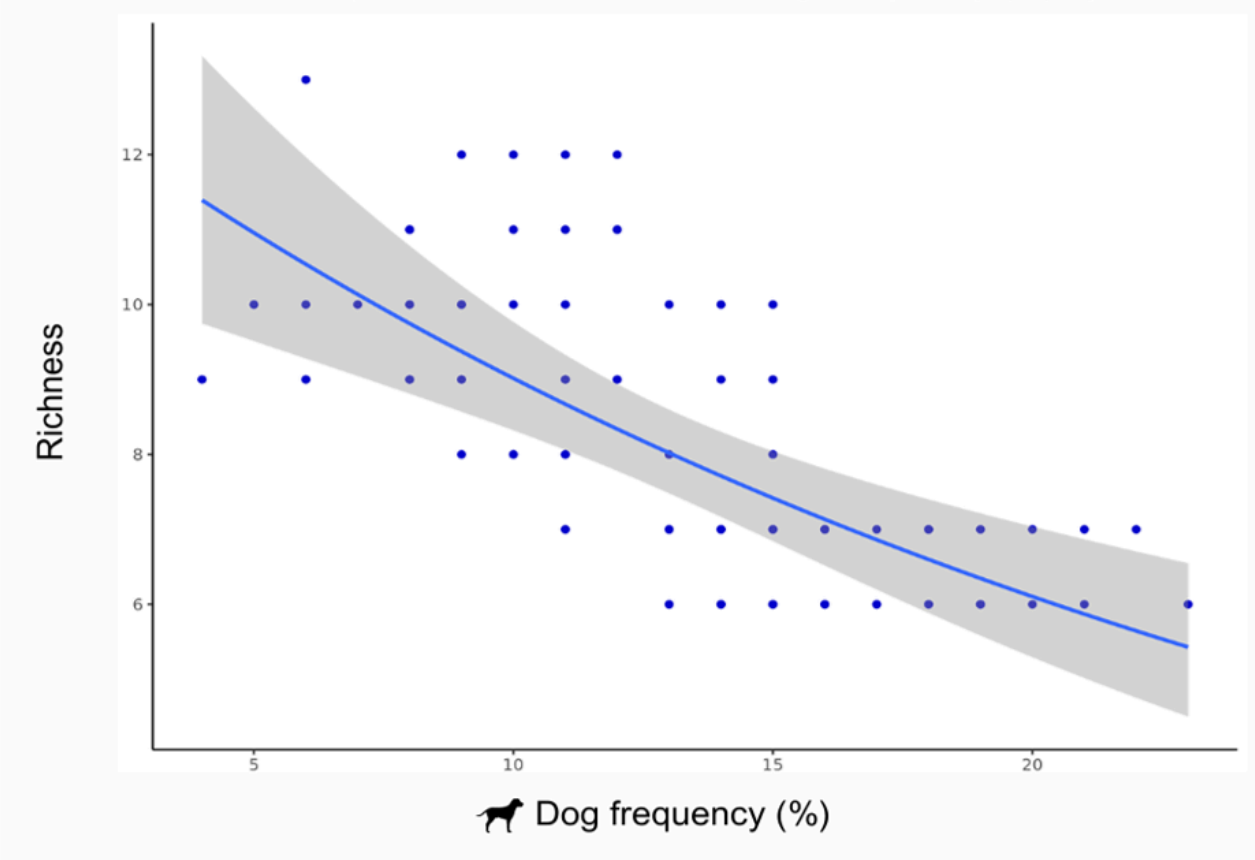


Figure 3

Generalized Linear Model associating domestic dogs' presence and wildlife species richness considering both free access and restricted access trails at the BG-UFJF. Blue dots represent species richness in each sampling site. The blue line indicates the predicted values from the model, and the gray shaded area represents the 95% confidence interval.